One object of Nordenskjöld's going to Greenland was to discover whether dogs could be used in Spitzbergen for extensive sledge journeys, with the result that he found that they could not be employed "in long sledge journeys in the regions where no game was to be had."

Nordenskjöld had not ceased to take an interest in public affairs, and represented the capital of Sweden in the Diet for 1869 to 1871, during which he managed to bring about some important legislative measures for the better promotion of science. In the Spitzbergen Expedition of 1872-73 Nordenskjöld spent the winter in Mussel Bay, the state of the ice having been in an unusually unfavourable condition. Among the results of the expedition Nordenskjöld mentions the following:—

> "The discovery on the Polar-ice itself of a dust of cosmic origin, containing metallic nickel-iron; researches by Dr. Kjellman on the development of algæ during the winter night, which at Mussel Bay is four months long; researches on the Aurora and its spectrum by Dr. Wijkander and Lieut. Parent, of the Italian Marine; researches by Dr. Wijkander on horizontal refraction in severe cold; a complete series of meteorological and magnetic observations in the most northerly latitude where such observations had up to this time been carried on; the discovery of numerous new contributions to a knowledge of the flora of the Polar countries during former geological epochs; a sledge excursion undertaken under very different circumstances by Palander and myself, whereby the north part of North East Land was surveyed, and a journey, very instructive in a scientific point of view, made over the inland ice of North East Land, &c., &c."

Then, in 1875, followed the expedition to the mouths of the Yennissei and Obi, the first of a series which culminated in the circumnavigation of Europe and Asia, of which we have just had such a full and instructive narrative.

Thus no one man has done half so much as Baron Nordenskjöld for a scientific exploration of the Arctic regions. The most striking characteristics of his various expeditions have been the small expense at which they were conducted, their modest but carefully-considered equipment, the clear and scientific methods on which they were planned, and the wealth and high value of the results obtained. In the intervals between the expeditions, Nordenskjöld was by no means idle. Not only was he occupied with his official duties as chief of the Stockholm Museum, but his researches in mineralogy, on the origin and constitution of meteors, on auroræ, and, in other important departments, are of the greatest moment. In 1876 he took part as a commissioner in the Philadelphia Exhibition; when he returned on July 1 of that year he stepped on board the vessel that was to take him on his second expedition to the Yennissei. We give the first of two articles on his researches on Auroræ, and hope shortly to give some account of his work in connection with Meteors.

As to the personal character of Baron Nordenskjöld we need say little, his modesty and geniality and his aversion to public display are well-known. He has in his adopted country risen to the highest honours, and as a well-earned reward for the success of his last expedition, the King of Sweden, his warm supporter, conferred on him the title of Baron. From scientific societies all over the world he has received honours. He is only yet in his prime; and is now preparing for another expedition to the shores of Siberia, and we trust he may long be spared to carry on the work in which it would be difficult to find a successor.

THE POSSIBILITY OF FINDING WORKABLE COAL-SEAMS UNDER THE LONDON AREA

IN a lecture recently delivered at the London Institution, an attempt was made to lay before a popular audience the course of reasoning, by which geologists have demonstrated that productive Coal-Measures may not improbably lie at no great depth beneath the metropolitan districts. The verification of the prediction that a ridge of Palæozoic rocks would be found to extend at a moderate depth beneath London, which has resulted from the borings made by Messrs. Meux and Co. in the Tottenham Court Road, and by the New River Company at Turnford and Ware, has renewed the interest which geologists have long taken in the question; and as the people of the metropolis now pay something like £5,000,000 a year for the carriage of coal from a distance, it appeared to be not unlikely that the general public might also be brought to take an intelligent interest in this important problem.

The discussion of the subject which has since taken place in the newspapers shows that such an expectation was not altogether unreasonable. But it must at the same time be confessed that some of the writers who have dealt with the subject have shown such a total misapprehension of the true nature of the problem, as to render it advisable to give in the pages of NATURE some explanations of the positions taken up by geologists in connection with the whole question.

As long ago as the year 1826, Dr. Buckland and Mr. Conybeare, in describing the features of the Bristol and Somerset coalfield, took occasion to point out how closely the Coal-Measures of that district resemble those of the great Belgian coalfield. This resemblance can be traced not only in the nature and succession of the strata in the two coalfields, but also in their positions and relations.

In the year 1841 MM. E. de Beaumont and Dufrénoy called attention to the fact that coal had been followed under newer beds in the North of France, and that possibly the same ridge of old rocks with coal-strata might stretch right away under the south-eastern counties of England.

In 1846 Sir Henry de la Beche gave much greater precision to the suggestion, and wrote as follows:—"From the movement of the older rocks many a mass of Coal-Measures may be buried beneath the Oolites and Cretaceous rocks on the east (of the Bristol Coalfield), connecting that district with those of Central England and Belgium, rolled about and partially denuded prior to the deposition of the New Red Sandstone."

In 1852 M. Meugy pointed out that it was by no means improbable that the coal basins of Belgium and Northern France would be found to extend right under the London basin.

But it is to Mr. Godwin-Austen that we are indebted for the most complete and philosophical discussion of the whole problem. In his well-known paper read before the Geological Society in 1855, he showed that the Coal-Measures, which had been proved to thin out under the

Chalk near Théronanne, would probably be found to make their appearance again near Calais, and to be prolonged beneath the Chalk and Tertiary beds along a line parallel to, if not coincident with, that of the North Downs, and thence away towards the Bristol and Somersetshire Coalfield.

In the Report of the Coal Commission, published in 1871, Prof. Prestwich has very ably argued the whole question, and brought forward a large amount of new evidence bearing upon it.

That geologists were right in their prediction of the existence of a ridge of Palæozoic rocks (the Axis of Artois), extending under the metropolitan area, has now been abundantly proved by boring operations. The strata of the Bristol and Somerset Coalfield have been traced and worked for a distance of about six miles under the overlying younger strata. That these overlying strata tend to thin away as they are followed towards the east has been proved by Prof. Hull and other geologists who have studied the Trias, Lias, and Oolites of the Midland district; and Prof. Prestwich has shown from a boring made at Oxford that the whole of the Lias and Oolites, which to the westward are several thousands of feet thick, beneath that city, are reduced in thickness to 420 feet. At Burford, in Oxfordshire, Coal-measure strata have actually been proved to exist at a depth of 1184 feet from the surface, and at Northampton at 830 feet. At Harwich, Carboniferous strata were found at a depth of 1026 feet; at Ostend, Palæozoic rocks were found at 975 feet; and at Vilvorde, near Brussels, at about 600 feet. These facts serve to show that a great attenuation of the Mesozoic strata takes place, as they were followed towards the south-east, and that the Palæozoic rocks are brought by so much nearer to the surface.

To the eastward, where the strata of the Belgian coalfield are found to be covered by overlapping younger strata, the productive measures have been followed by the enterprising French mining engineers, by means of pits sunk through the tertiaries and chalk, and in this way valuable coal supplies have been obtained along nearly the whole of the line from Mons and Charleroi to Lillers. At Hardinghen, between Calais and Boulogne, coal-measures are, in consequence of upheaval and denudation, exposed at the surface, while near the former town, strata of Carboniferous age have been found at a depth of 1138 feet.

The interesting experimental boring put down at Battle in Sussex, in order to prove the depth of the oolites beneath the Wealden, resulted in a very interesting discovery. It was found that in this district the Jurassic strata are of considerable thickness, and that it is therefore hopeless to attempt to reach the Palæozoic axis in that part of the Wealden area.

Five deep borings have however demonstrated the very moderate depth at which the Palæozoic rocks lie in the Metropolitan district. At Tottenham Court Road the Palæozoic ridge was found at a depth of 1066 feet; at Kentish Town at 1114 feet; at Turnford, near Cheshunt, at 940; at Ware at 796 feet; and at Crossness, near Erith, at 1008 feet. The exact age of the beds reached at Kentish Town and Crossness is somewhat doubtful, but at Tottenham Court Road and at Turnford the Upper Devonian was found, and at Ware the Wenlock shales of the Upper Silurian. We are indebted to Mr. Etheridge for a careful study of these borings, and for the determination of the numerous fossils obtained from them.

Another interesting fact demonstrated by these borings is that the strata lie at very high angles, the dip found at Tottenham Court Road being 36°, and that at Ware 30°.

The evidence obtained from these borings proves that the rocks forming the old Palæozoic ridge are bent into a series of east and west folds, and among these folds it is highly probable that Coal-measure strata will be found.

As to the point at which a boring might be put down with the greatest chance of success, several different opinions exist.

Prof. Prestwich thinks that a point in the southern suburbs of London, such as Sydenham or Croydon, is well worthy of being selected as the site for a new trial, and he points out that, even if coal were not found, the Lower Greensand might be met with, and this would in all probability be found to afford such an abundant supply of excellent water that the money expended in the investigation would not be thrown away.

Mr. Godwin-Austen, believing that a probable correspondence will be found to exist between the modern and ancient lines of disturbance, suggests some point near the North Downs, which is the axis of a great post-Cretaceous flexure, as the most hopeful one.

Some authorities have favoured the idea that it will be wise to avoid the task of sinking through the chalk, by commencing south of the North Downs, while others, foreseeing some difficulties in putting down borings and shafts through the loose running sands of the Folkestone beds, are in favour of a renewed attempt in more northern points of the Wealden district. But in face of the facts revealed by the Battle boring and the known thickness of the Wealden, it may well be doubted if it would be advisable to commence so far away from the proved position of the Palæozoic axis.

The coal-basins, if they exist on this Palæozoic ridge, are probably long and narrow in form, like those of Belgium and Northern France, having their longer axes directed from east to west. We now know that the Palæozoic ridge lies at depths varying from 800 to 1200 feet below the surface in the London district. As coal is profitably worked in many pits in this country more than 2000 feet deep, there is no reason why the coal, if discovered, should not be mined under London. We are now, therefore, in a position to state what are the requirements for a systematic search for coal under this city, and the conditions under which that search must be made.

This question, which is one of such paramount importance to the people of London, would probably be completely set at rest, if a series of borings were put down along a line running from Hertford on the north to Redhill on the south, a distance of less than forty miles. Considering the probable narrowness of the coalfields (that of Belgium averages less than four miles in width) the borings ought to be only a few miles apart, and thus at least ten or twelve borings with a probable average depth of 1000 feet would be necessary. But, of these required borings, four have already been executed, those namely at Ware, Turnford, Kentish Town, and Tottenham Court Road; and thus only six or eight more borings would be necessary. With the improved methods of working by the diamond rock-drill, these borings could probably be carried to the depth of 1000 feet at the cost of a few thousands of pounds, and this would be a very moderate sum to pay for settling such a highly important question. It is of course possible that only two or three of these borings would be required, and the order in which they should be executed must be in a great measure determined by the results which were obtained by those first put down. Probably it would be well to commence with the sites suggested by Prof. Prestwich and Mr. Godwin-Austen respectively, namely, Croydon or Sydenham, and a point near the North Downs.

The only chance of this line of borings missing the coal-bearing strata would result from the circumstance that the coal-troughs are not continuous, but are, in all probability, like those of Belgium and Northern France, separated by pre-Cretaceous upheaval and denudation, along lines crossing the great axis, into separate long and narrow basins. It is therefore just possible that a boring might reach a point lying between two such basins. It would follow from this that while the Coal-measures, if they exist, would in all probability be found by such a systematic search as we advocate, yet the failure to discover them would not absolutely demonstrate their absence in the whole of the Metropolitan district.

Since it is the people of London who would mainly benefit by the discovery of coal under their city, it is by them that the effort to raise the comparatively moderate sum of money required for such a systematic search as we have advocated must be made. When the magnitude of the interests at stake is remembered, it is surely not too much to hope that, so soon as the people of this city fully realise the importance of the evidence brought forward by geologists, they will be prepared to make the necessary effort to secure the decision of the question in the only way that is practicable, namely, by actual experiment.

Some of those who have recently engaged in this discussion have taken it for granted that the great smoke-pall that too often rests over this city would necessarily be increased by the discovery of coal beneath London. They have therefore stigmatised geologists as "Philistines," resolutely bent on destroying all the little "sweetness and light" left to the unfortunate inhabitants of London. But it is by no means certain that any such effects would follow from the discovery of coal in the metropolitan area. It must be admitted that the beautiful landscapes of our home counties would not be improved if coal-tips, engine-houses, and winding-gear were to rise in all directions about them, but the reduction of coal and gas bills to one-half or one-third of their present amount would, by most London householders, be regarded as a sufficient compensation for such disadvantages. Judging from the character of the coals found in the Bristol and Somerset and the Belgian coalfields, it is probable that while gas- and caking-coals would not be wanting, a great part of the coal under London would prove to be anthracite and hard coals. Every one who has visited the Smoke Abatement Exhibition must be convinced that there is a great future for such varieties of coal. The people of London who are reluctant to alter the construction of their grates so as to adapt them to the use of such coals, at their present prices, might find it well worth their while to do so if those prices were reduced to one-half or one-third of what they are at present.

In this way the discovery of coal under London might lead the way to that general reform in our domestic hearths, which we all desire, but which we find it so difficult to realise; and thus, perhaps, the discovery of coal at a moderate depth beneath us, paradoxical as the suggestion may appear, may lead to the purification of our London atmosphere.

JOHN W. JUDD

THE ENCYCLOPÆDIA BRITANNICA

The Encyclopædia Britannica. Ninth Edition. Vol. XIII. Inf.—Kan. (Edinburgh: A. and C. Black, 1881.)

IT is impossible to do justice in detail to all the leading scientific articles in this volume; we can only express our satisfaction of the admirable manner in which the publication keeps to the level of its first promise. We have only space to glance at one or two articles, regretting that those on "Instinct," by Mr. Romanes; "Insectivorous Plants," by Mr. P. Geddes; "Iron," by Dr. Alder Wright; "Kangaroo," by Prof. Flower, and others of equally high mark, can only be mentioned.

In Mathematics the *pièce de resistance* is a very carefully digested article upon the *Infinitesimal Calculus*, by Mr. B. Williamson, F.R.S., who has already won his spurs in this field by his two treatises on the Differential and Integral Calculus. In a former notice we expressed ourselves somewhat hesitatingly upon the utility of elaborate articles upon branches of mathematics in a work of this kind, but the "Calculus," we think, lends itself more readily to such treatment than almost any other branch. Certainly the subject, in the hands of Mr. Williamson, is handled in such a way that the student, so far as the text is concerned, will be independent of any of the usual textbooks, and will only require to consult them for exercises to try his hand upon, to test his acquaintance with the principles herein so clearly unfolded and aptly illustrated. The advanced mathematician also will find not only sufficient matter for his purpose, but, what is more serviceable to him, a ready means of reference to the original sources of information. In this respect we cannot speak too highly of the care bestowed on all parts of the two divisions into which the Infinitesimal Calculus bifurcates. The narrative of the contributions of Legendre, Gauss, Abel, and Jacobi to elliptic functions, in the concluding portion of the paper, is an admirably lucid exposition of the relative positions of these great analysts in this department. Mr. Williamson devotes 120 columns to the practical portion of his article: in these he naturally treads on the lines he has pursued in his previous works. He follows the subject of *Envelopes* with a sketch of *Symbolic Methods*, first started by Arbogast, who was succeeded by François, Servois, and in more recent times by Hargreave, Boole, and Crofton. He gives useful reference here also to Hankel and Grassmann, who have treated symbolic methods in a comprehensive manner. Another novel section in this connection